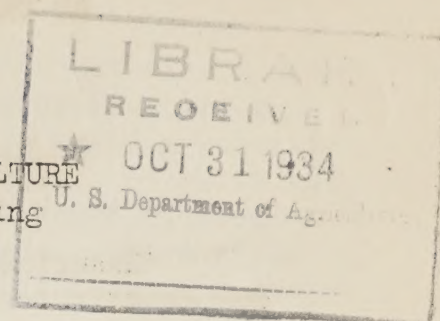


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UNITED STATES DEPARTMENT OF AGRICULTURE
Bureau of Agricultural Engineering
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LATEST RESULTS OF ENGINEERING EXPERIMENTS
AT THE SOIL EROSION EXPERIMENT STATIONS

by

C. E. Ramser, Senior Drainage Engineer

Delivered at the Annual Meeting

of the

American Society of Agricultural Engineers

at

Detroit, Michigan

June 20, 1934

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Experiments designed to improve the practice of terracing constitutes the major part of the engineering investigations being conducted on the ten soil erosion experimental farms of the U. S. Department of Agriculture. These experiments are intended primarily to obtain information on the proper spacing, grade, height, cross section, and limiting lengths of terraces for any particular soil or land slope. Studies are also being conducted on the methods of constructing and maintaining terraces, the improvement of machinery for building terraces and farming terraced land, the proper size, location and control of terrace outlet ditches and improved methods of farming terraced land.

In most of the experiments, the measurements of soil and water losses from terraced and unterraced land under various cropping conditions constitutes the principal means of ascertaining the relative effectiveness of terraces of different design in controlling erosion. A special effort has been made to keep all but one factor constant in each experiment so as to eliminate any questionable influence of a second variable factor upon the experimental results. For instance in a terrace spacing experiment the different terraces in the experiment may have vertical spacings of 3, 5 and 7 feet but the grade, the height and the length of the terraces, and the tillage methods and cropping practices are kept the same. Also an effort was made to locate each experiment so there is a minimum of variation in the type of the soil and the slope and erosive condition of the land. These variations which are difficult to eliminate or control, for many reasons, are in many cases known to have an adverse effect upon the value of the results of the experiments and often require considerable time before detected and completely corrected. For instance, if a gully crosses one terrace in an experiment and not another the depression left in the channel above the terrace would tend to act as a settling basin and eroded soil would settle out instead of being carried to the measuring device at the end of the terrace.

Measurements of the run-off water from the terraced and unterraced lands are made with the Parshall measuring flume and a silt sampler was specially designed for making measurements of the soil erosion losses. These devices were described in an article entitled "Soil Erosion Control on the Federal Projects" published in the Journal of Agricultural Engineering, April, 1930. Some slight improvements have been made in the silt sampler since this article was published but the principle employed to extract a proportionate sample of the run-off water remains essentially the same. (Fig. 1).

NOTE: Figures referred to in this paper will be furnished the reader upon request.

The Parshall measuring flume is regarded as the best direct measuring device that can measure with a satisfactory degree of accuracy the entire flow of water from a stream or channel with varying velocity without first passing the water through a stilling basin. Since it was desired to obtain the rate of flow of the water as it was delivered at the end of the terrace, no measuring weir or device requiring a stilling basin for its accuracy was regarded as being satisfactory for these experiments.

Much more difficulty is encountered in obtaining a satisfactory measurement of the soil carried off the field than in measuring the run-off. This is due principally to the fact that leaves, grasses, stalks and other material interfere seriously with any attempt to take water samples proportionate to the total flow at any instant. Several devices were developed that would collect satisfactory samples of clear water or of water containing moderate amounts of debris but failed completely when operating under field conditions during storms causing maximum debris conditions. The sampling slot of one experimental device completely clogged up by fine hairs in what appeared to be perfectly clear water.

The silt sampler finally decided upon for these experiments collects the heavier silt in the run-off water in a box or basin and a sample of the run-off water as it passes over a weir at the outlet end of the box. (Figure 2) The silt trapped in the box can be accurately measured and this often represents as much as half of the total silt. The possibility of debris interfering with taking the sample of the run-off water is reduced to a minimum by taking the sample out by means of a slot in the side of the box which is protected by a self-cleaning screen. The screen at no place extends at right angles to the direction of the flow of the water so that the running water tends to wash off any debris which may collect on the screen. Attempts to place the sampling slot at right angles to the direction of the flow resulted in the clogging of the slot or the protecting screen. This silt samples does not depend upon the sample of water taken out by the slot for the measurement of the total run-off water, which would result in a large error if the slot should be partially clogged part of the time during a storm. The water is accurately measured by means of the Parshall flume. Also it does not depend entirely upon the sample taken out by the slot for the determination of the total silt in the run-off water since a large amount of the silt is collected in the silt box amounting in some cases to half as much as the total silt in the run-off water.

TERRACES CONSERVE BOTH WATER AND SOIL

Results obtained on the relative losses of soil by erosion from terraced and unterraced lands demonstrate conclusively the great value of terraces as conservers of the soil. The longest record supporting the above statement has been obtained at the Guthrie, Oklahoma Station where a full three years record has been obtained. This record shows an annual loss for a three year period of 64.1 tons of soil per acre as compared with an average of 2.2 tons per acre from a terraced are, the loss from

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the terraced land being only 3.4 per cent of that from the unterraced land. The soil and slope were practically the same on both areas, they were cropped essentially the same and the average rainfall for the three year period was about normal. In Table no. 1 are given similar results for the other stations where reliable data has been collected and the yearly results for Guthrie. Also in this table are given the per cent of the rainfall that ran off from terraced and unterraced land. These results show that in addition to conserving the soil, terraces are effective in conserving more of the rainfall than unterraced land. For the stations in the middle west the run-off from unterraced land ranges from about 3 per cent more for the Bethany Station to about 62 per cent more for the La Crosse Station than from terraced land during periods of one to three years. At the Pullman Station in Washington the run-off is nearly 200 per cent more from the unterraced than from the terraced land. In the measurement of soil losses from terraced fields it is recognized that there is some movement of the soil down the slope, part of which reaches the terrace channel and near the upper end of the terrace there is not sufficient volume of run-off water to carry away this soil to the outlet end of the terrace. This movement on uniform slopes free from the concentration of water, however, is so slow that no appreciable soil movement has been detected from accurate measurements of ground surface elevations on lines at right angles to the contours of the field over a period of five years at Guthrie. A similar movement of soil down the slope of unterraced areas exists which it is logical to assume is much greater than on terraced areas owing to the possibility of the concentration of a greater volume of water with its greater power to erode on the longer slopes. As in the case of the terraces however, all of this soil does not reach the foot of the slope or a water channel and is not carried off the field. In both cases this soil, which in the case of the terrace has moved a short distance down the slope and in the case of the unterraced land, a considerable distance down the slope, is not measured as a part of the soil loss from the field, and since the soil on the unterraced land has moved further down the slope it would seem that the method employed for comparing soil losses from terraced and unterraced land tends to favor the unterraced land.

TERRACE GRADE IMPORTANT FACTOR IN REDUCING SOIL LOSSES

Excellent results have been obtained at both the Guthrie and Bethany Stations on the effect of terrace grade upon soil losses for several different grades. In Figure 3 are shown graphically the soil losses during one year for terraces with different grades when the terraces at both stations were cropped to corn. It is seen from the table that the losses for a 6 inch grade at Bethany^{are} nearly 5 times as much as for a terrace with a level grade and about 3 times as great as for a terrace with a 2 inch grade while at Guthrie it is nearly 4 times and over 2 times as great respectively. In Table No. 2 are given the soil losses for terraces with different grades at all of the stations where satisfactory data has been obtained.

Table No. 18

TABLE NO. 1

Run-off and Soil Losses From Terraced and Unterraced Land at Several Soil Erosion Experiment Stations

Experiment:	No. of Terraces or Watershed	Period: Years	Annual Soil Losses In Tons Per Acre	Annual Run-off In Per Cent Of Rainfall	Average Slope Of: 100 Feet	Crops	Annual Rain-Fall Inches				
			Terraced: Under-raced:	Terraced: Under-raced:	Terraced: Under-raced:						
Guthrie	Watershed 13: Terrace 6-C	1931	1.25	43.90	2.8	10.7	22.7	5.5	5.1	Young Oats* Mature Cowpeas: Fallow	27.3
Guthrie	Watershed 13: Terrace 6-E	1932	4.06	88.06	4.6	23.3	30.8	5.5	5.1	Fallow Cotton Winter Wheat Winter Wheat Cotton	36.2
Guthrie	Watershed 13: Terrace 6-E	1933	1.33	60.39	2.2	21.9	14.1	4.6	5.1	Later Grass in: Cotton	30.4
	Average Annual		2.21	64.12	3.4	18.6	22.5			Cotton	31.3
Tyler	Watershed 4: Terrace 7-C	1933	4.55	41.03**	11.1	14.0	16.5	5.8	7.5	Cotton Followed by Fall Oats	45.7
La Crosse	Watershed 4: Terrace 20 to 40	1933	2.23	31.70	7.0	4.9	8.9	12.7	13.1	Barley Followed: by Clover Corn Followed:	26.8
Bethany	Watershed D3: Terrace 2-E	1933	3.19	27.09	11.8	18.7	19.2	8.3	6.7	By Sweet Clover: Winter Wheat Following peas Winter Wheat	31.7
Pullman	Watershed 4: Terraces 5, 7 and 17	1932	2.35	22.53	12.6	10.0	24.8	About 20:	About 20:	Winter Wheat Stubble	24.4
	Watershed 4: Terraces 5, 7 and 17	1933	3.53	11.26	31.3	12.4	37.3	About 20:	About 20:	Winter Wheat Stubble Fallow Winter Wheat	28.8
Pullman	Watershed 4: Terraces 5, 7 and 17										
	Average Annual		3.19	16.90	22.0	11.2	31.0				26.6

*Crops are given for terraced area. Crops for untterraced area are Winter rye, mature cowpeas and winter wheat
 **Gullies and watercourse protected by brush dams.

TABLE NO. 2

Run-off and Soil Losses for Terraces With Different Grades at Several of the Soil Erosion Stations

		Average Annual				Crops	
Terrace:	Land Slope:	Vertical Length:	Grade	Soil Losses:	Run-off In:	Rainfall	
Number:	Per Cent	Spacing:	Feet:	Inches Per:	Per Cent Of:	In	
		Feet	100 Feet	Acre	Rainfall	Inches	
Guthrie Station:							
				(3 year	Period)		
3-C	4.3	3.5	1500	7.79	20.2		1931 - Oats
4-C	4.4	3.5	1500	4.29	20.6	31.3	1932-Cotton
5-C	4.7	3.4	1500	3.53	20.6		1933 - Corn
6-C	5.5	3.3	1500	2.05	16.6		
Bethany Station:							
				(2 year	Period)		
5-C	12(Approx):5	(Approx):1200	8	3.92	13.2		1932 - Corn
6-C	12(Approx):5	(Approx):1200	6	1.87	12.0		1933--Oats followed by
7-C	12(Approx):5	(Approx):1200	4	1.66	12.0	29.4	clover and timothy
8-C	12(Approx):5	(Approx):1200	2	0.68	11.0		
9-C	12(Approx):5	(Approx):1200	0	0.42	6.8		
Tyler Station (3 year							
				Period)			
5-C	6.3	4	700	10.1	29.8		1931 - Cotton) followed by
6-C	5.9	4	700	4.9	16.2	42.3	1932 - Corn) rye and oats
							1933 - Cotton) cover crop
La Crosse Station (1 year)							
4-A	15(Approx):	7	1400	7.1	-		1933 - Barley followed
5-A	15(Approx):	7	1400	2.0	-	26.8	by corn
6-A	15(Approx):	7	1400	0.6	-		
Pulman Station (1 year)							
15	24.0	17.0	685	13.67	29.3		Winter Wheat stubble
16	26.7	13.5	780	11.40	23.2		1933 - Fallow
17	23.5	14.2	780	9.05	13.6	28.8	Winter Wheat
18	18.4	14.0	780	3.65	11.6		
13	15.2	13.8	780	1.28	15.1		

Appreciable scouring in the terrace channels with 6 inch and 8 inch grades was apparent at both Guthrie and Bethany. At Guthrie, the yields of cotton and corn were less for the level terrace and for the terrace with the 6 inch grade. The smaller yield in the level terrace channel was attributed to partial drowning or excess moisture in the channel and in the channel with 6 inch grade to the washing out of some of the small plants due to the high velocity of the water. From these results it appears that sufficient grade should be given a terrace to provide satisfactory drainage of the terrace channel and yet not so much as to cause appreciable erosion.

It is seen from the table that level terraces with open ends are more effective in conserving both the soil and water losses at Guthrie and Bethany, the soil losses from a level terrace being about 50 per cent and 25 per cent, respectively for the two Stations, of that from a terrace with a uniform grade of 4 inches per 100 feet, and the water losses from a level terrace being about 80 per cent and about 60 per cent respectively of that from the 4 inch grade terrace. The slight damage that is done to crops in level terrace channels is partly offset by the effectiveness of this terrace in conserving more of the soil and water particularly for open permeable soils. At Tyler, Texas level terraces on gentle slopes and sandy soils have given very satisfactory services where carefully built and maintained. One of the important things to remember about level terraces is that they require more care in maintenance and construction than a graded terrace. One neglected low place in a level terrace will result in the water pouring over, coming from both directions along the terrace. A similar low place in a graded terrace particularly near the upper part of its length where the channel is never filled may result in no overtopping since the cross section of the channel below the top of the low place is often large enough to carry the moving water along the channel and by the low place in the terrace embankment.

SOIL LOSSES INCREASE BUT WATER LOSSES
DECREASE WITH LENGTH OF TERRACE

The results of a two years experiment at the Tyler Station continue to show that soil losses increase with the length of the terrace. The average annual soil loss for a terrace 1,700 feet long was about 20 per cent greater than for a terrace 700 feet long. On the other hand, the longer terrace conserves more of the rainfall. The percent of rainfall running off was 22.8 per cent for the short terrace and only 16.7 per cent for the long terrace. Similar results were obtained for long and short terraces on the Station at Pullman, Washington where during a two year period the soil loss for a terrace 2,300 feet long was over twice as large as for a terrace 800 feet long and the percent of the rainfall running off for the short terrace was over double that from the long terrace.

BOTH SOIL AND WATER LOSSES GREATER FOR UNIFORM
THAN FOR VARIABLE GRADED TERRACES

A uniform graded terrace at Bethany having a grade of 4 inches per 100 feet gave a soil loss about 37 per cent greater and a water loss about 33 per cent greater than a variable graded terrace having a grade of 1 to 4 inches per 100 feet during a two year period. Both terraces were 1,200 feet long, had vertical spacings of 5 feet and were on the same land slope. Also for the three largest storms that occurred during the year 1933 the average of the maximum rates of run-off during the storms for the uniform graded terrace were slightly over twice as great as for the variable grade terrace. Similar results were obtained on the Station at Tyler, Texas where the soil loss was about 15 per cent greater and the water loss 27 per cent greater for a uniform than for a variable graded terrace. Also the rate of run-off from one of the largest storms was about 40 per cent greater for the uniform graded terrace.

From these results it is apparent that the variable graded terrace is not only more efficient in conserving both soil and water but does not require as great a height as the uniform graded terrace due to the smaller maximum rate of run-off or maximum discharge during storms. The flatter grades near the upper end of a variable graded terrace tend to store or hold back the upper water until the water below has a chance to flow off. This prevents the concentration or piling up of the run-off water near the lower or outlet end of the terrace so that a lower terrace embankment can be used for a variable graded terrace under the same field and rainfall conditions without the possibility of overtopping. These advantages of the variable graded terrace over the uniform graded far outweigh a minor objection, namely, that the variable graded terrace is slightly more difficult to lay out in the field than the uniform graded.

SOIL LOSSES INCREASE WITH TERRACE SPACING ON
CULTIVATED LAND

Results obtained during 1933 at Guthrie confirm the results for 1931 which showed that soil losses increased for increase in terrace spacing when the land was planted to a clean cultivated crop such as corn. The results for the two year period at Guthrie show that the average annual soil losses in tons per acre were 2.65, 4.15 and 4.97 tons per acre for vertical spacings of 2, 3 $\frac{1}{2}$, and 5 feet respectively on a land slope of about 5 $\frac{1}{2}$ per cent. Similar results were obtained for the Tyler Station, the average annual soil losses for the experiment being 3.68, 5.47 and 5.74 tons for terraces with vertical spacings of 3, 4 and 5 feet on a land slope of about 7 per cent during a 3 year period when the land was planted each year to clean cultivated crops, cotton in 1931 and 1933, and corn in 1932.

Results at Guthrie for the year 1932 when the land was in oats showed very little difference for the different spacings. In fact the greater losses occurred for the smaller spacing but the difference was not large enough nor the record long enough to warrant any conclusions.

It appears that this difference in results for clean cultivated and grain crops is due to the development of small gullies on the wider terrace spacing when in cultivated crop and the absence of such gullies when in grain crop. Wider spacings permit a greater concentration of the run-off water particularly on non-uniform and irregular slopes and gullying increases with the distance travelled by the concentrated water. This results in a greater accumulation of soil in the terrace channel at points of concentration for the wider spacings. This greater deposit of soil in the channel of the terrace with wider spacing results in greater soil losses for wider spacings particularly for long terraces with large drainage areas since the volume of water removed by such terraces especially near the outlet end is sufficient to carry away a large part of the soil deposited in the terrace channel. Since the velocity and thereby erosive power of the water increases with the grade of the terrace, no doubt the greater the grade of the terrace the greater will be the increase in soil losses with increase in terrace spacing.

EFFECT OF DIFFERENT CROPS UPON RUN-OFF AND SOIL EROSION LOSSES

A paper could be written on this subject covering the results obtained on the Bethany experiment station alone where the most comprehensive experiments are being conducted on the control of erosion by crops and crop rotations. The experiments have not progressed far enough yet to justify definite conclusions but results so far do show that not much dependence can be placed on such crops as wheat to control erosion due principally to the fact that heavy rains are liable to occur at the time of seeding and preparation of the seed bed or shortly thereafter. The following is taken from the report of A. T. Holman, in charge of engineering experiments on the Bethany Station and relates to results obtained from a terracing experiment with different crops:- "If the terraces are combined to make a full wheat year, it was found that there was a loss of 8.15 tons per acre for the wheat year of 1933, and the loss during the wheat year of 1932 was 2.62 tons per acre. The average erosion loss for the two wheat years was 5.38 tons of soil per acre, which is only 10.6 per cent less than the 6.02 tons per acre eroded from corn land during the same period. These high losses from wheat were caused in part by the coincidence of a hard rain occurring right after wheat seeding. This condition, however, is not unusual for in 1930 and 1931, as well as in 1933, there were hard rains during or following wheat seeding. This indicates that in terracing for wheat, the same terrace design and care should be used as in terracing for corn land".

Over a two year period at Bethany the average annual soil losses in tons per acre from terraced land in different crops were as follows: Soybeans followed by wheat, 7 tons; corn on contour, 6.33 tons; wheat followed by clover and timothy, 2.42 tons; oats and sweet clover followed by corn, 1.87 tons; and clover, timothy, and lespedoza, 0.4 ton. From this it is seen that clover and timothy are quite effective in reducing erosion losses as compared with wheat, soybeans and corn.

COMPARISON OF CROP YIELDS ON TERRACES
AND UNTERRACED LAND

At the Tyler Station in 1931 an unterraced area yielded 29 per cent more seed cotton per acre than an adjoining comparable terraced field, the terraces having been built during the preceding winter. In 1932 the terraced area produced 9 per cent more and in 1933, 47 per cent more than the unterraced area. Thus during a period of three years a change in yields has occurred from a 29 per cent greater yield for the unterraced area than the terraced, to a 47 per cent greater yield for the terraced than the unterraced area. The low yield for the year 1931 was undoubtedly caused by the disturbance in soil conditions when the terraces were built during the preceding winter.

GENERAL DISCUSSION

From the results of the foregoing experiments it is evident that terraces should be spaced close enough together to prevent the concentration of water and appreciable erosion on the land slope between the terraces. In the spacing of terraces, however, another important factor must be carefully considered and that is the ability of the terrace channel to carry away the run-off water which is delivered to it from the land slope between the terraces for rains of high intensity. As has been found from experiments the amount and rate of movement of the water that runs off between the terraces depend upon the nature of the soil, the vegetative cover, the land slopes, the amount and intensity of the rainfall, and the shape, length, and size of drainage area.

The ability of a terrace channel to carry away the run-off water delivered to it depends upon the shape, the fall, the cross-sectional area, and the frictional resistance to flow. The discharge capacity of the channel is computed by the formula $Q = CA / RS$

where

Q = The discharge in cubic feet per second,
C = A coefficient representing the frictional resistance to flow,
A = The cross-sectional area in square feet,
R = The hydraulic radius depending upon the size and shape of channel,
S = The fall of the bottom of the channel.

The results of terracing experiments on the experiment stations will enable the engineer to determine all of the above factors in computing the discharge capacity of a terrace channel. This is particularly important since terrace failures due to exceeding the discharge capacity of the channel and resulting in the water's overtopping and breaking the terrace are of common occurrence where unscientific guesses have been relied upon instead of fundamentally sound experimental data.

A terrace channel must not only be able to remove the water from the drainage area between the terraces but must accomplish this without excessive erosion in the terrace channel. In other words, it must conduct the water to the terrace outlet at a low, non-eroding velocity. Both the fall and the shape of the channel can be controlled so as to produce the desired velocity for any particular soil.

A broad, shallow channel will have a lower velocity than a deep, narrow channel. To illustrate, the two channels shown in Figure 4 are capable of removing the same quantity of water from the drainage area in the same time but the broad, flat channel removes it at a comparatively low velocity of 1.44 feet per second and the narrow, deep channel at a velocity of 2.29 feet per second, a velocity sufficient to cause erosion. The deep channel has a cross-sectional area of only 12 square feet as compared with a cross-sectional area of 19 square feet for the shallow channel. The shape of the channel alone, due largely to the fact that the line in the cross-section with which the water comes in frictional contact is only 9.4 feet for the deep channel and 26.1 feet for the shallow channel, is responsible for the small deep channel carrying as much water as the large shallow channel.

From the foregoing it has been seen that the control of erosion in a terrace channel can be accomplished to a limited extent by the shape of the channel. This alone would of course not be effective if the fall of the channel were not limited. Results of experiments on the soil erosion experiment stations at Guthrie, Oklahoma; and Bethany, Missouri indicate the effect of fall of broad shallow terrace channels upon erosion and show conclusively that the soil losses from a terraced field increase appreciably with the grade of the terrace. In order to reduce the soil losses it is necessary to lower the erosive and silt carrying capacity of a terrace channel by limiting the grade and thereby the velocity in the channel. The minimum grade should be used that will be effective in removing the run-off water from the contributing drainage area between the terraces which increases with the length of and distance between the terraces. It is believed that in most practical terracing work a grade of 4 inches per 100 feet need not be exceeded and that satisfactory control can be obtained from the standpoint of erosive action in channel and silt carrying power of the water for grades not exceeding 4 inches per 100 feet for most types of soils.

From the foregoing discussion it can readily be seen that considerable ingenuity must be exercised in planning terrace embankments on different land slopes so that the cross-sectional area of the channel will be sufficient to take care of the run-off water; so that appreciable erosion will not occur in the terrace channel; and so that the shape of the terrace embankment will not be such as to interfere with the easy operation of machinery in farming the embankments. The type of an embankment will necessarily not be the same on a steep slope of 15 per cent as on a comparatively flat slope of only 3 per cent in order to meet satisfactorily the foregoing requirements.

The height of a terrace determines largely the cross-sectional area of the water-way for any particular slope. The higher the terrace, however, the more interference with the operation of farm machinery. If the height of a terrace is kept low in order to meet farm machinery requirements, this may require reducing the drainage area by a closer spacing of the terraces in order to prevent the run-off water from overtopping the low terrace embankment. Thus it is seen that the interdependence of factors governing the design of a terrace is such that if a change in any one is made, readjustment of the remaining factors becomes imperative in order to restore the proper balanced relation of the various factors.

The control of erosion in terrace outlet ditches or gullies is a much more difficult problem than in terrace channels. The same principles apply but the general practice of an outlet ditch carrying the water to the foot of the slope along a natural depression or through an artificial channel often located directly down a slope along a road or a fence results in a large fall in the outlet ditch.

The velocity in the channel may be reduced somewhat by using a ditch with a broad shallow cross section but not sufficiently to prevent erosion. Additional protection against erosion is required by either further reducing the velocity or protecting the channel with a short growth of grass which will not reduce too much the water carrying capacity of the ditch. Even on moderate slopes it has been found advisable and necessary in most cases to cause an equal distribution of the water across the bottom of the channel by means of planks buried on edge in the ground at close intervals across the channel and with their upper edges about flush with the bottom of the channel. If this is not done there is a tendency for the water to concentrate and cause serious erosion. Also the plank holds the grass in place and checks any small gully erosion that may start between the planks. This method of control has been found to be quite effective on moderate slopes and for limited drainage areas as shown in the view which was taken on the Bethany Soil Erosion Experimental Farm near Bethany, Missouri. Figure 5.

Ditches with large drainage areas or on steep slopes cannot be very effectively controlled by the foregoing method. Also it is not always possible in all locations to build a broad shallow ditch or in some sections of the country to secure a satisfactory sod in the ditches. Under these circumstances control of the ditch or gully is usually accomplished by means of check dams built of a variety of temporary or permanent material and so spaced in the ditch that the crest of one dam is about the same elevation as the foot of the next dam above. A separate paper would be required to discuss the results of experiments on check dams in gullies and terrace outlet ditches being conducted on the soil erosion experiment stations. Particular emphasis is being placed upon cheapness of construction, keeping in mind of course the importance of building effective and stable structures. Local materials if adapted for building purposes are preferred when found to provide the most economical structure that will afford satisfactory service.

The length of time that the experimental farms have been in operation vary from $1\frac{1}{2}$ years at Zanesville, Ohio to about $5\frac{1}{2}$ years at Guthrie, Oklahoma. About 2 years is required before much data of value is obtained so that not much data of a conclusive nature have been collected at the more recently established stations. More time will be required at some of the stations where the rough condition of fields have tended to prolong the period of adjustment required to secure the necessary uniformity of conditions governing terraces in each experiment. Also the length of time that the experiments have been in progress at most of the stations is not sufficient to permit making any conclusive comparisons of results obtained at the various stations owing to differences in soil conditions, annual rainfall, rainfall intensities, topography, crops, farming practices and seasonable conditions favorable or unfavorable to growing crops.

